MUDS

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1. Purpose

To handle a broad array of transient signals for research and practical applications with low or high latency for deployment and run-time modification is an expensive, complex, and time-consuming endeavor. The hardware for such work can be expensive and the software required to utilize such hardware can be costly to produce and maintain. In certain circumstances such hardware may only be fully utilized for multiple users, therefore, the ability to coordinate, establish priority, and protect hardware is of importance. A requirement may exist to be able to afford remote accessibility to these users and these functions in themselves add further expenses in the form of software development.

The reasoning for handling a broad array of transient signals may be:

- for a body of scholarly work in improvement, understanding, or creation of existing radio technologies
- monitoring of the radio spectrum for surveillance
- cosmological study of radio frequency or transient light array signals

In a classical setup, the ability to coordinate, organize, prioritize, and manage many projects utilizing shared hardware could be inefficient and error prone to both hardware and other users. The ability to provide remote access to this hardware will also be made very difficult since in a classical setup each piece of hardware will be required to be configured independently for access and also there will exist no ability to govern the allowance or disallowance of operation of such hardware which might affect other users. To circumvent these problems, a system is needed that provides prioritized, safeguarded, and controlled access to hardware. In many cases, such hardware might be general computational or specialized computational and thus control of usage of this hardware will need to be governed in order to ensure that the resources required for a higher priority user or process are not disturbed by a lower priority process. Also, such classical setups may require excessive downtime as components are reconfigured, bridged, multiplexed, and de-multiplexed since all would reside in a decentralized state, therefore, a solution is needed to unify all components with reduced or eliminated downtime for reconfiguration, coordination, organization, and priority management.

There is also a necessity to utilize parallel computation of such transient signals due to the computational load exceeding single physical systems, and to do this in a cost-effective manner would require the realization of scalability of a solution. The solution would have to scale across physical machines while still providing the coordination, protection, manage, and organization of resources to multiple users.

The ability to provide a multi-user system specialized for digital transient signal processing which enables coordination, prioritization, protection of resources, remote access, extensibility, and ease of I/O to external sources

2. MUDS

The *Multi User Digital Signal Processing System* shall establish the ability to coordinate, prioritize, provide remote access, and enable the creation or application of safeguards to the encompassed hardware. It shall provide the infrastructure that decreases complexity, cost, and development time to provide these abilities. It shall provide robust scalability that is agnostic to computation hardware supporting the system.

3. Multi-User

A system may be quite expensive relative to the monetary support of its user, therefore, it may be required that it is used by multiple personnel. To facilitate this, a system should be able to provide some form of resource protection, coordination, and priority between the users.

4. Remote Access

By providing resource protection is it such that the hardware for the system has safeguards that prevent usage beyond specification tolerances. For example, specific hardware may not have intrinsic safeguards for operation beyond maximum tolerance specifications, therefore, a system would be well suited to be a layer between the user and the hardware in order to prevent damage. In a less trivial case, it may be that the system could be exhausted of all distributed processing capability, thus, being detrimental to any practical of experimental processes currently engaged in the operation.

The priority between users allows sharing of the resources without comprehensive and error-prone communications between the users. If a project of high priority was able to be detrimentally disturbed by one of a lower priority than the safeguards

would have been considered inadequate, therefore, the ability to establish an adequate prioritization of running processes in such a system is paramount to successful usage by multiple users.

The coordination between users is enabled by the system providing the means in which to schedule priority and exclusive usage by a set of rules that dictate what shall be allowed or disallowed during the time of operation for such processes. For example, an experimental or practical radar system may be enabled at a facility where this facility's hardware is governed under this system, and this radar system may be sensitive to certain frequency transmissions or operation of specific hardware, therefore, the system would provide the means for this radar processes and project to disallow or allow certain usages and operations during a specified range of time where the range of time may be for minutes, hours, or months.

5. Research and Practical Application

The research and practical applications for such a system overlap since practical applications stem from research, therefore, discussion of applications for one also apply to the other. The term research used therein is primarily indicative of the flexibility of the infrastructure to accommodate work that may have no standardized means for which is provided by the infrastructure but that system has a focus that is directed to providing the ability to create the means.

6. Control Signal and Data Signals

The system will be supportive of both control and data signals. These differ in the sense that the control signals are used to alter or monitor the acquisition of the data signals. A control signal may be one that switches the antenna for a specific channel in the system as a whole, or it may be used to acquire instrumentation data on the operation of components external to the system.

7. Low or High Latency Processing

The processing of signals may be performed with low-latency, as in real-time, or it may encompass the delayed processing of signals. A signal may be delayed in completed processing if the signal data rate is too high for real-time processing, or perhaps resources are only available for processing at a later time.

8. Deployment

The deployment of such a system shall need to be robust in order to enable utilization of varying types of hardware. The base of the system will be required to reside on general purpose computational hardware with data communications ability in order for remote access to be possible the system will need to be able to have robust support or ease of including support for various communication mediums and protocols. This robust support could be provided by the underlying operating system without any modification or extension of the base system, however, the system should be able to handle extension or modification if needed.

The deployment should be able to encompass some standardized forms of equipment and services such as:

- Internet access and communication protocols (TCP, UDP, HTTP, HTTPS)
- general computational hardware (X86, ARM, AVR)
- specialized computational hardware (FPGA)
- bulk or specialized data acquisition hardware
- control hardware or signal outputs
- instrumentation hardware or signal sources

9. Scalability

To centralize adequate computational power, the system will utilize disjoint physical systems. This utilization will happen through means of communications whereby *MUDS* will establish an internal channel between these disjoint physical systems in order to orchestrate such coordination. By having disjoint physical systems, the potential can be realized to perform more complex calculations in parallel without having to physically administrate the components at each physical location. This also allows for small physical distances to be bridged such as those commonly found in supercomputers whereby the physical distance is small but significant.

10. Run-Time Modification

The state of the system needs to be modifiable during runtime to prevent downtime which would reduce efficiency. The ability to add, remove, and configure components of the system during run-time is critical to reducing downtime and also the interruption of ongoing processes that may be used for experimental, research, and practical applications that exist on the system.

11. Infrastructure for Transient Signal Processing

The infrastructure shall provide means of performing common processing operations out of the box such as:

- normalization
- phase shifting
- statistical measurements
- demodulation

- multiplexing
- inverse multiplexing

11.1. Web Based Interface

To provide administrative functionality for users of the system it is only logical that existing robust technologies be leveraged and such of these would be that *MUDS* would provide a standard web-based control interface. The Web provides highly configurable technologies for providing control for users of the system. It also provides some potentially limited applications of external data capture and processing as an extension of the system to the local user's machine.

12. External Data Capture And Release

The ability to capture data from *MUDS* by the user for further storage, processing, and inspection is absolutely critical and therefore, facilities for the acquisition of this data shall be provided. It is also critical that for systems which contain hardware that instead receives data that the system provides the ability for users to release this data into the system. The ability to capture and release data shall be realized through a variety of means such as the following:

- Web Sockets (web based interface)
- TCP
- UDP

13. Conclusion

A system that can provide coordination, prioritization, resource protection, multi-user remote access, and allow simple scalable utilization of hardware of varying

configuration the ability to accomplish scientific, private, academic and practical end goals can be realized in a cost-effective manner. This setup is akin to a cloud in that many resources are pooled for coordinated usage except that this endeavor is specialized for transient signal processing of a large amount of data potentially in real-time.